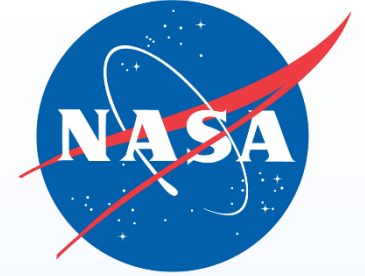


National Aeronautics and Space Administration



# NASA Electronic Parts and Packaging (NEPP) Program Status and Technology Investments Overview

## *Responsive Technology Assurance for Civil Space*

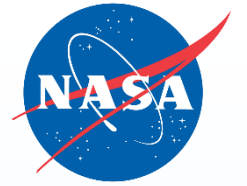
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This work was sponsored by NASA Office of Safety & Mission Assurance



# Acronyms

Abbreviation	Definition
AF	Air Force
BGA	Ball Grid Array
BN	Bayesian Network
BoK	Body of Knowledge
CMOS	Complementary Metal Oxide Semiconductor
COTS	Commercial Off the Shelf
CPU	Central Processing Unit
DDR	Double Data Rate
DLA	Defense Logistics Agency
DMEA	Defense Microelectronics Activity
DoD	Department of Defense
DoE	Department of Energy
EEE	Electrical, Electronic, and Electromechanical
ETW	Electronics Technology Workshop
FPGA	Field Programmable Gate Array
GaN	Gallium Nitride
GIDEP	Government Industry Data Exchange Program
GPU	Graphics Processing Unit
GRC	Glenn Research Center
GSFC	Goddard Space Flight Center
GSN	Goal Structuring Notation
HQ	Headquarters
IC	Integrated Circuit
IEEE	Institute of Electrical and Electronics Engineers
JPL	Jet Propulsion Laboratory
JSC	Johnson Space Center
LaRC	Langley Research Center
LGA	Land Grid Array
MAPLD	Military and Aerospace Programmable Logic Devices (Workshop)
MBMA	Model-Based Mission Assurance
MRAM	Magnetic Random Access Memory
MSFC	Marshall Space Flight Center

Abbreviation	Definition
NASA	National Aeronautics and Space Administration
NEPAG	NASA Electronic Parts Assurance Group
NEPP	NASA Electronic Parts and Packaging (Program)
NESC	NASA Engineering and Safety Center
NODIS	NASA Online Directives Information System
NPR	NASA Procedural Requirement
NRO	National Reconnaissance Office
NSREC	Nuclear and Space Radiation Effects Conference
OCE	Office of the Chief Engineer
OGA	Other Government Agency
PIC	Photonic Integrated Circuit
POC	Point of Contact
PoF	Physics of Failure
RF	Radio Frequency
RH	Radiation Hardened
RHA	Radiation Hardness Assurance
SAPP	Space Asset Protection Program
SDRAM	Synchronous Dynamic Random Access Memory
SEE	Single-Event Effects
SiC	Silicon Carbide
SMA	Safety and Mission Assurance
SMC	Space and Missile Systems Center
SOA	Safe Operating Area
SoC	System on a Chip
SRAM	Static Random Access Memory
SSAI	Science Systems and Applications, Inc.
STMD	Space Technology Mission Directorate
STT	Spin Transfer Torque
SysML	System Modeling Language
TID	Total Ionizing Dose
TSV	Thru-Silicon Via



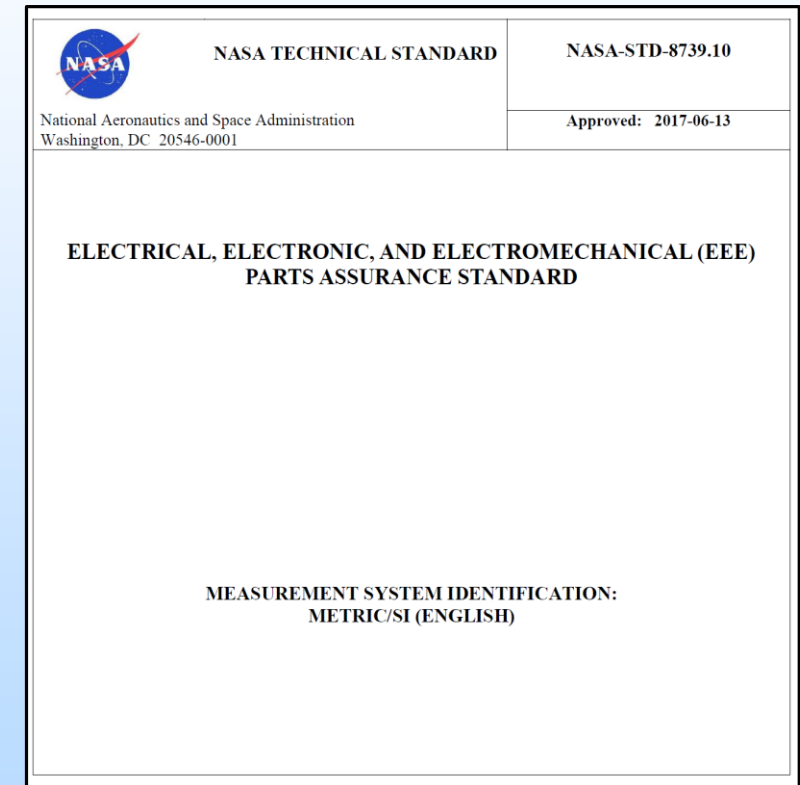
# Outline

- **Continued evolution of NASA Electrical, Electronic, and Electromechanical (EEE) parts management**
  - EEE Parts Manager & NEPP Program structure
  - General NASA EEE parts interfaces
- **NEPP Program overview for 2019**
  - What's new?
  - Key efforts and recent developments
  - NASA Electronics Parts Assurance Group (NEPAG)
    - Audits, community coordination, knowledge dissemination, and standards development
- **Summary**



# NASA EEE Parts – Evolving Structure

- **NASA EEE parts consolidation:**
  - Primary agency test and analysis activities will be at the **Goddard Space Flight Center (lead Center)** and the **Jet Propulsion Laboratory**
  - Agency EEE Parts Manager leads
- **NEPP Program remains the same:**
  - Owns the EEE parts assurance processes and related technical efforts
  - NEPP Program management evolution
- **New NASA-wide document activities**
  - NASA-STD-8739.10 released
  - EEE-INST-002 update
  - NPR 8705.4 update



<https://standards.nasa.gov/>



# NASA EEE Parts – Interfaces

## Agency EEE Parts

*(NASA Electronic Parts Manager – Steward & Advocate for Capability)*

Assurance

Office of Safety  
& Mission  
Assurance

- **NEPP Program**
- Quality
- Reliability
- Workmanship

Development

Office of the  
Chief Engineer

Capability Leadership  
NESC

Facilities

Flight Projects

Field Centers  
Mission Directorates

Mission Support

Space Environments  
Testing Management  
Office

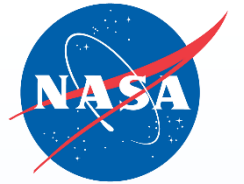


# NEPP Overview – Mission Statement

**Provide NASA's leadership for developing and maintaining guidance for the screening, qualification, test, and reliable use of EEE parts by NASA, in collaboration with other government agencies and industry.**

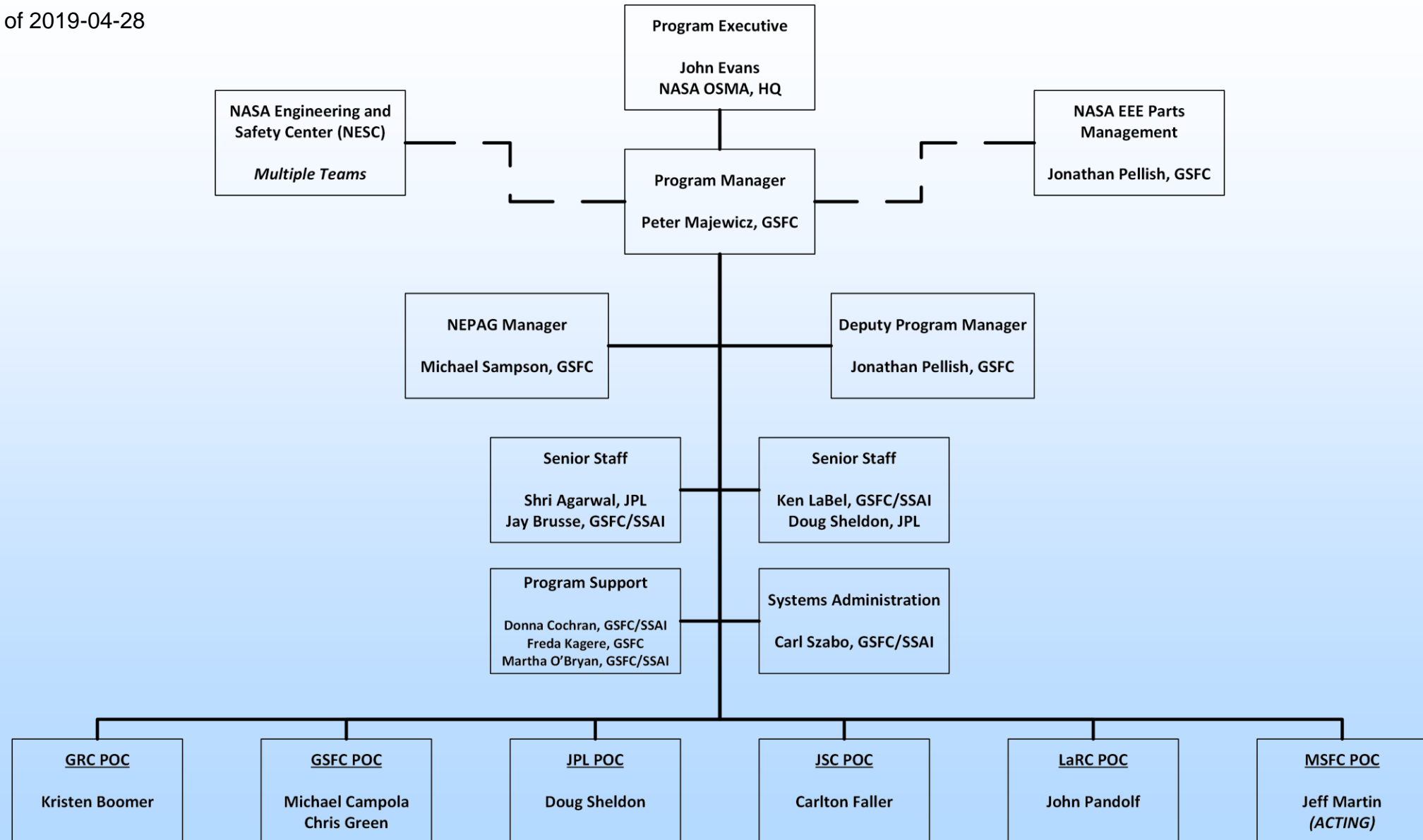
**Accessible & Product-Oriented**

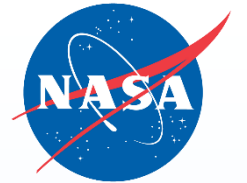
***Note: the NASA Electronic Parts Assurance Group (NEPAG) is a core portion of NEPP***



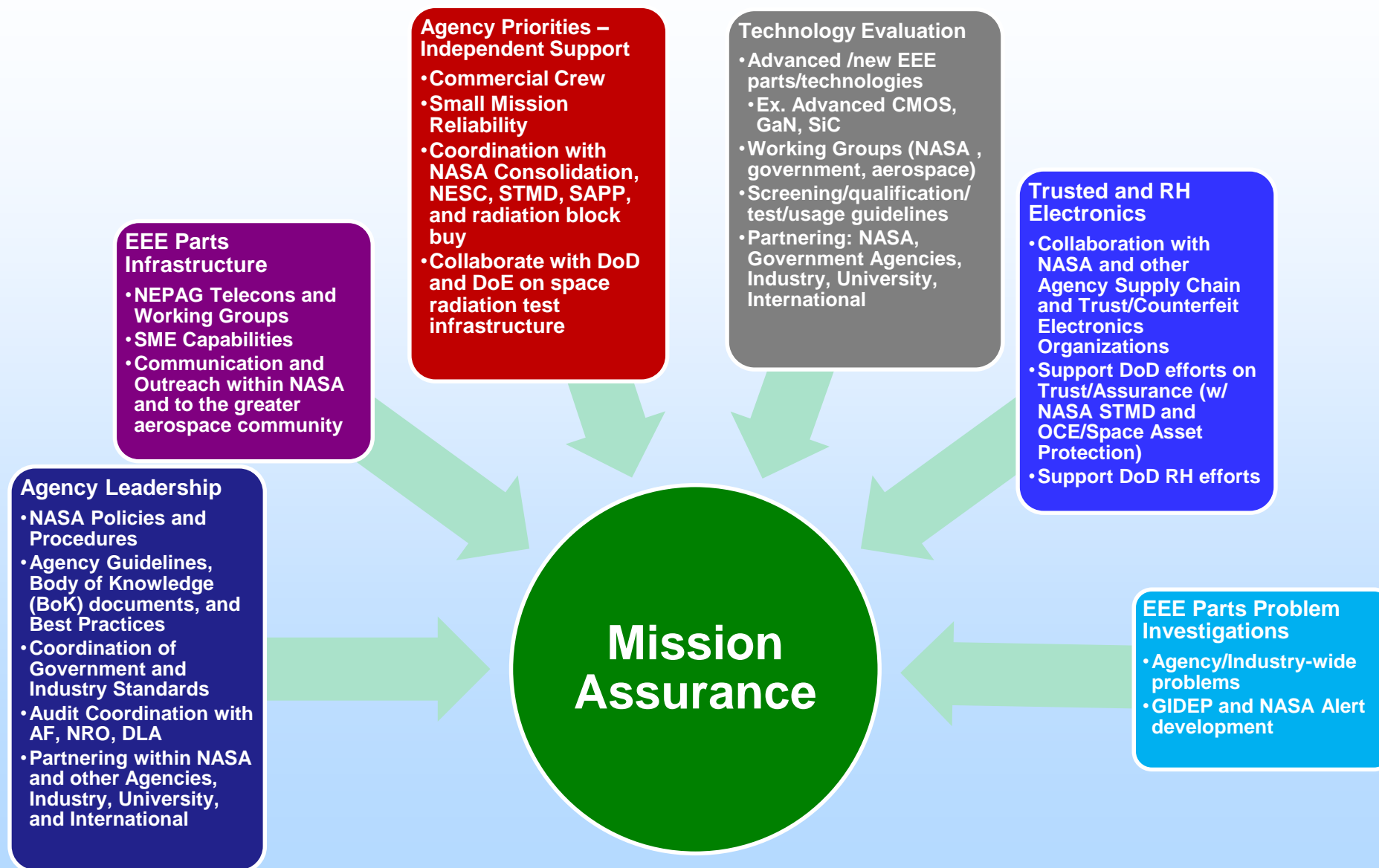
# NEPP Program – Organization Chart\*

\*as of 2019-04-28

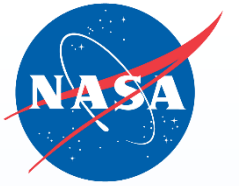




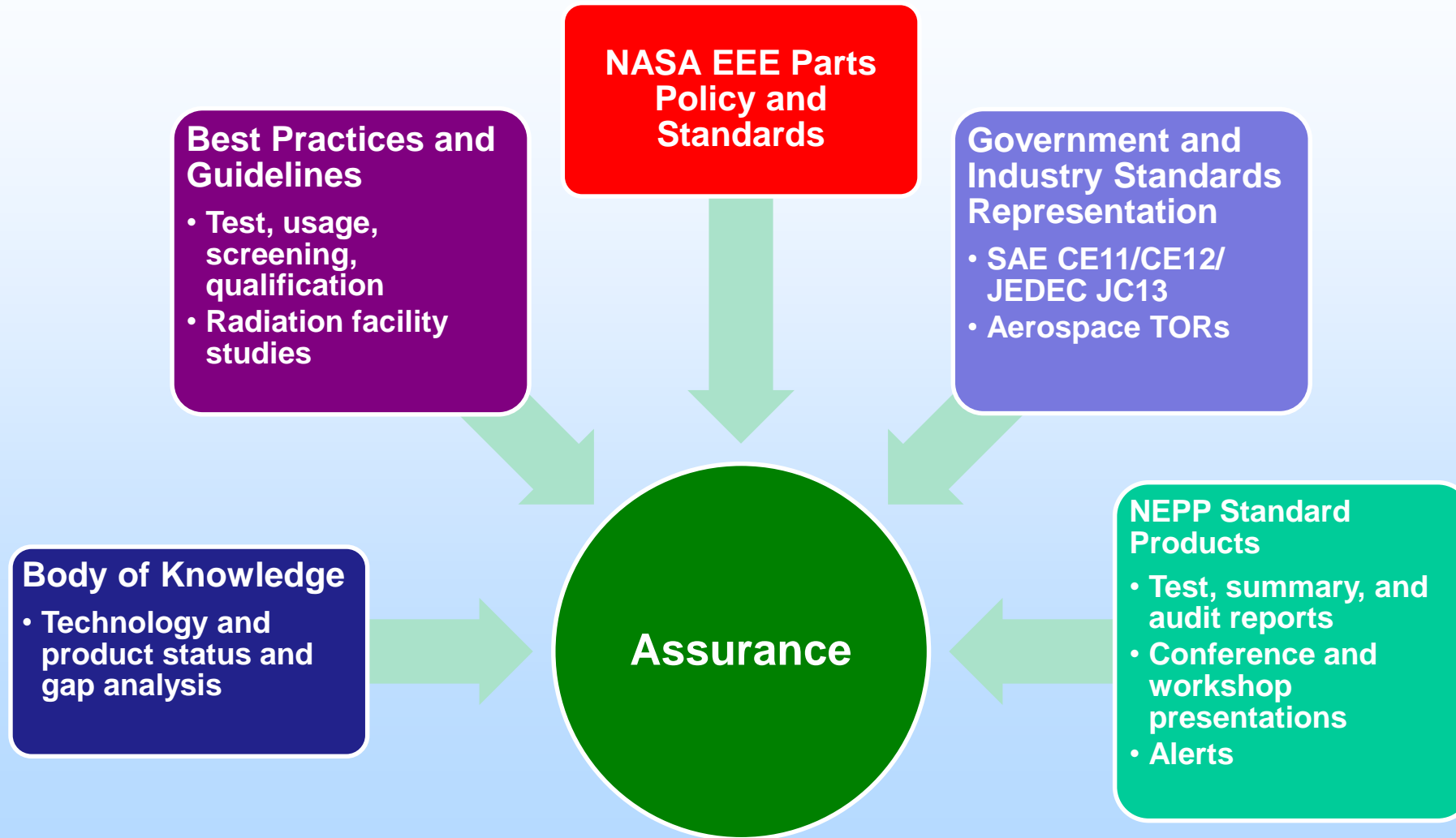
# NEPP Charter Breakdown







# NEPP Product Delivery



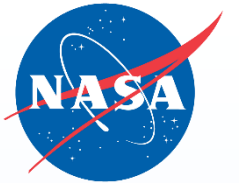


# Selection of NEPP FY2019 Highlights

- Increasing focus on advanced packaging
- Maintaining broad efforts in radiation hardness assurance
- Executing SmallSat industrial base assessment (major support from AF/SMC)
- Supporting evaluation and comparison of *Fides* vs. Physics-of-Failure (PoF)-based EEE parts reliability assessment – university grant kicked off in April 2019
- Examining opportunities for more significant integration of NEPP documentation into future community-consensus products
- Continuing delivery of standard assurance products / services
- Continuing support of Government Working Group and NEPAG teleconferences
- Selection of product deliveries:
  - BoKs released: [graphics processing units](#)
  - BoKs & guidelines to be released: optoelectronics, 2.5D/3D ICs, board-level proton testing, and SEE testing of system on a chip (SoC) devices
  - Other documents in the works: GaN, Small Mission RHA, SOA for Schottky diodes (radiation), SiC radiation testing, update to general proton testing guideline to include medical facility and low-energy guidance, LGA packages, and ongoing radiation and reliability test reports

# High-Energy Proton Test Facility Availability

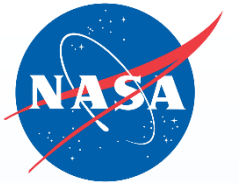
*(NEPP Program Continues to Monitor and Update)*



Organizations Selling Time Now – More Details Presented at SEE Symposium/MAPLD Workshop & NEPP ETW

Organization	Location	Notes
James M. Slater MD Proton Treatment & Research Center	Loma Linda, CA	BUSY! Booked well in advance at this time.
Northwestern Medicine Chicago Proton Center	Warrenville, IL	Fairly busy, but some weekend time still available throughout the year.
Proton Therapy at University of Cincinnati Medical Center	Liberty Township, OH	Dedicated research room with plans for access during days (interleave w/ 5-10 minutes/hour for user) and in evenings & weekends. A few folks have gone here, but biological experiments have had a higher load than expected. TBD on how many yearly hours, but time is currently available.
Provision CARES Proton Therapy Center	Knoxville, TN	Customers started. Have taken multiple customers (government, industry). Up to 1000/hrs a year planned. Currently have open bandwidth for access.
MGH Francis H. Burr Proton Beam Therapy Center	Boston, MA	BUSY! Booked through 2019. 3 out of 4 weekends a month access.
TRIUMF Proton Irradiation Facility	Vancouver, CAN	Several cycles of access a year with two beam lines

**This is a moving target - new facilities, changes in management, changes in operational loads, etc. all play into access. We reach out to the facilities regularly as a community service.**



# Current Technology Focus Areas

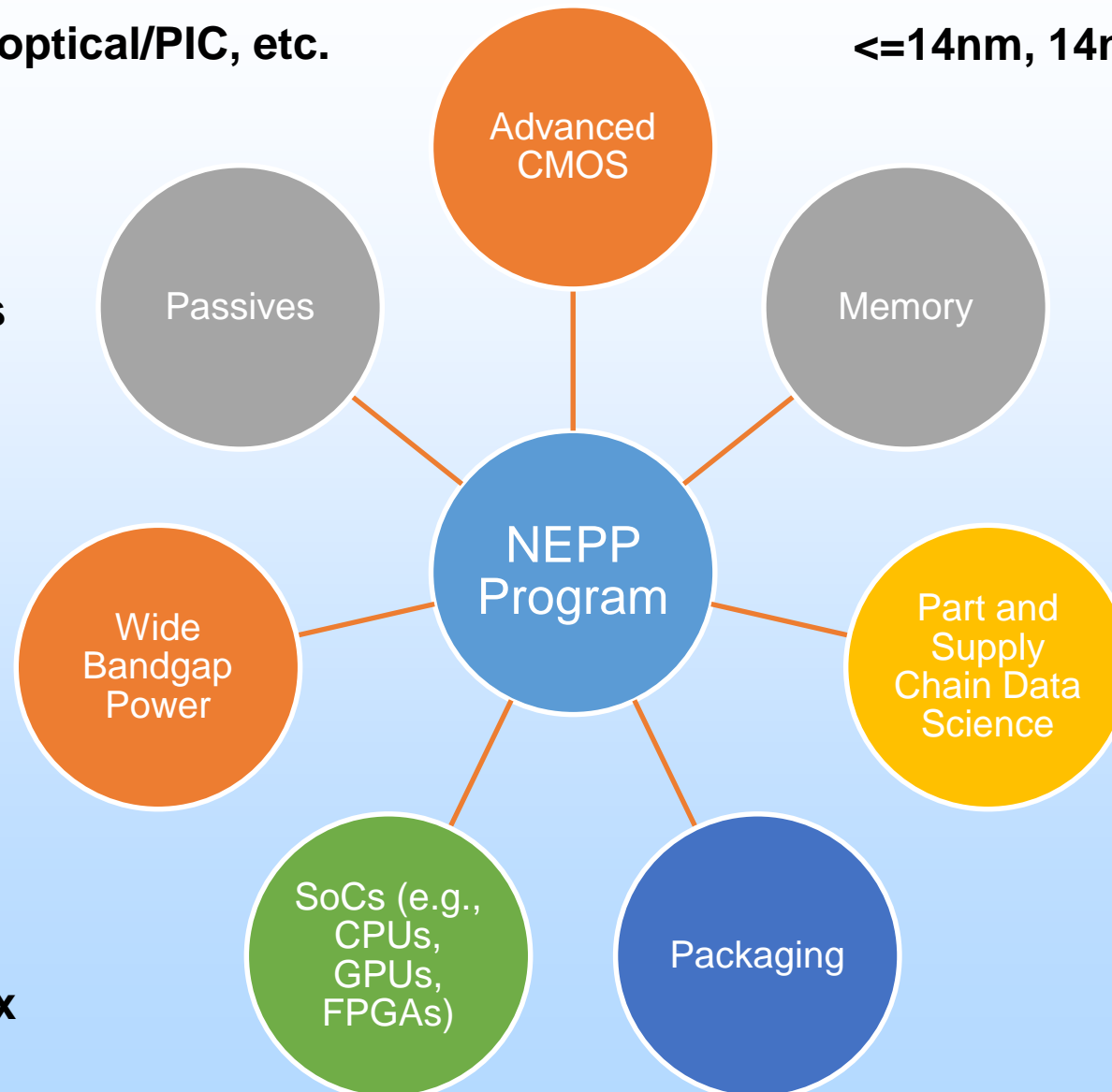
Other: data conversion, optical/PIC, etc.

$\leq 14\text{nm}$ , 14nm, 22nm, 32nm, & 45nm

Capacitors and resistors

GaN (enhancement mode & RF) and SiC

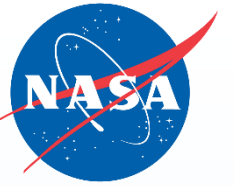
AMD, Intel, Microsemi, Nvidia, Qualcomm, Xilinx



Crosspoint, Discrete & Embedded STT-MRAM, NAND / NOR, & SDRAM

Supply Chain Studies, Web Scraping, Metadata Analysis, Formal Methods

2.5D / 3D solutions, Evolving Market Considerations, Support for Qualification Efforts



# Advanced Technology Evaluation Examples

## Select Radiation Test Efforts

ARM processor evaluation

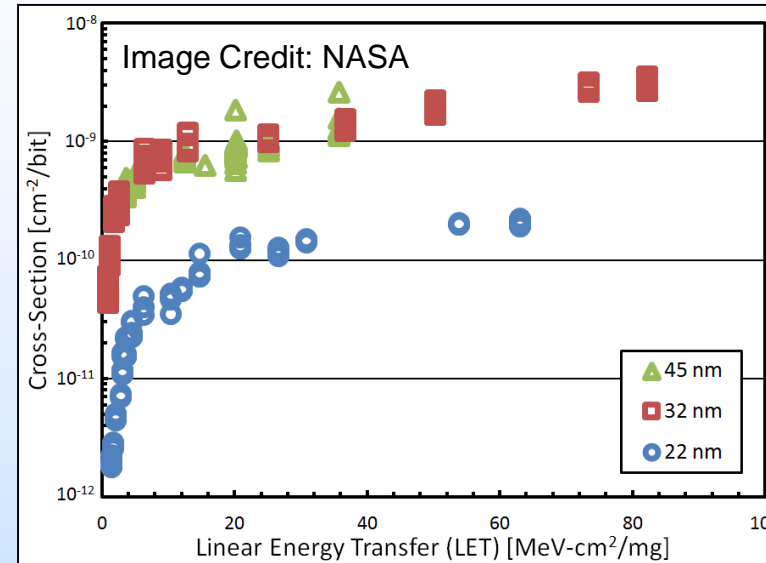
COTS power modules for smallsat applications (various vendors)

FPGA collaboration – 20nm Xilinx XCKU040 testing (SEE & TID)

Snapdragon processor evaluation

G. Allen, S. Guertin, et al., NASA JPL-Caltech

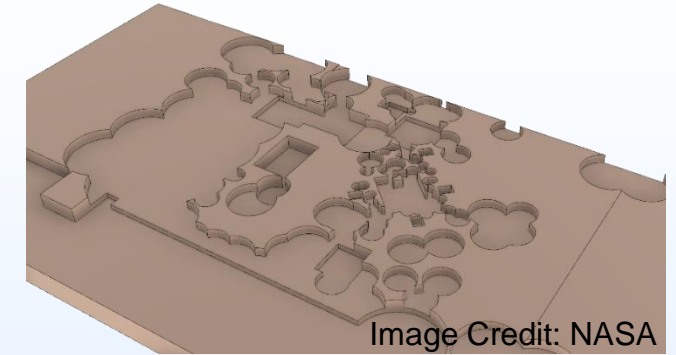
GF 22FDX TID testing March 2019;  
more SEE May 2019



**Heavy ion cross sections**  
**GlobalFoundries 45 & 32 nm PDSOI, 22 FDSOI**  
**Static Random Access Memories (SRAMs)**

M. Casey et al., IEEE NSREC 2018.

Collaboration with DMEA, Sandia, and GlobalFoundries



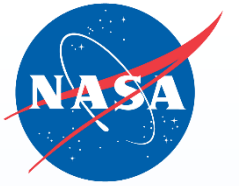
**AMD e9173 Discrete GPU (14nm Global)**  
**Board without heatsink and cold plate adapter**

E. Wyrwas et al., NASA GSFC

**Pace of technology evolution and growth of evaluation requirements continue to generate new demands:**

**1) diversified subject matter expertise; 2) more access to a wider variety of radiation test facilities**





# Advanced Packaging Highlights

## Selected Task Areas

- 2.5D packaging guidance
- BGA underfill selection and application guideline
- LGA interposer development
- Underfill technology assessment BoK
- Wafer-level 3D package reliability guidance

## Cu Pillar Flip Chip Collaboration

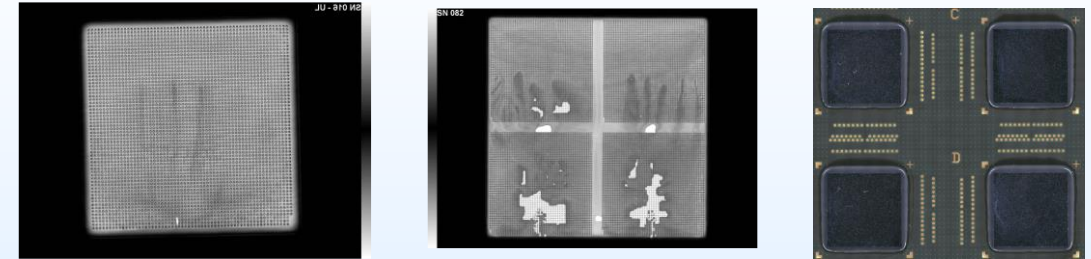


Image Credit: NASA

## DDR4 TSV Study

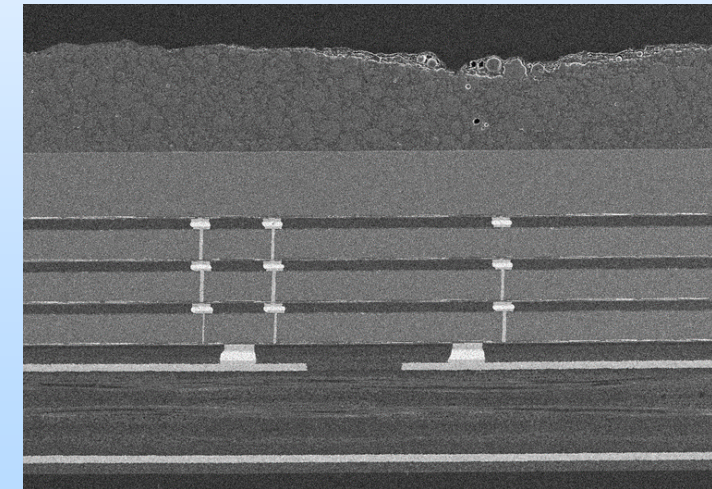


Image Credit: NASA

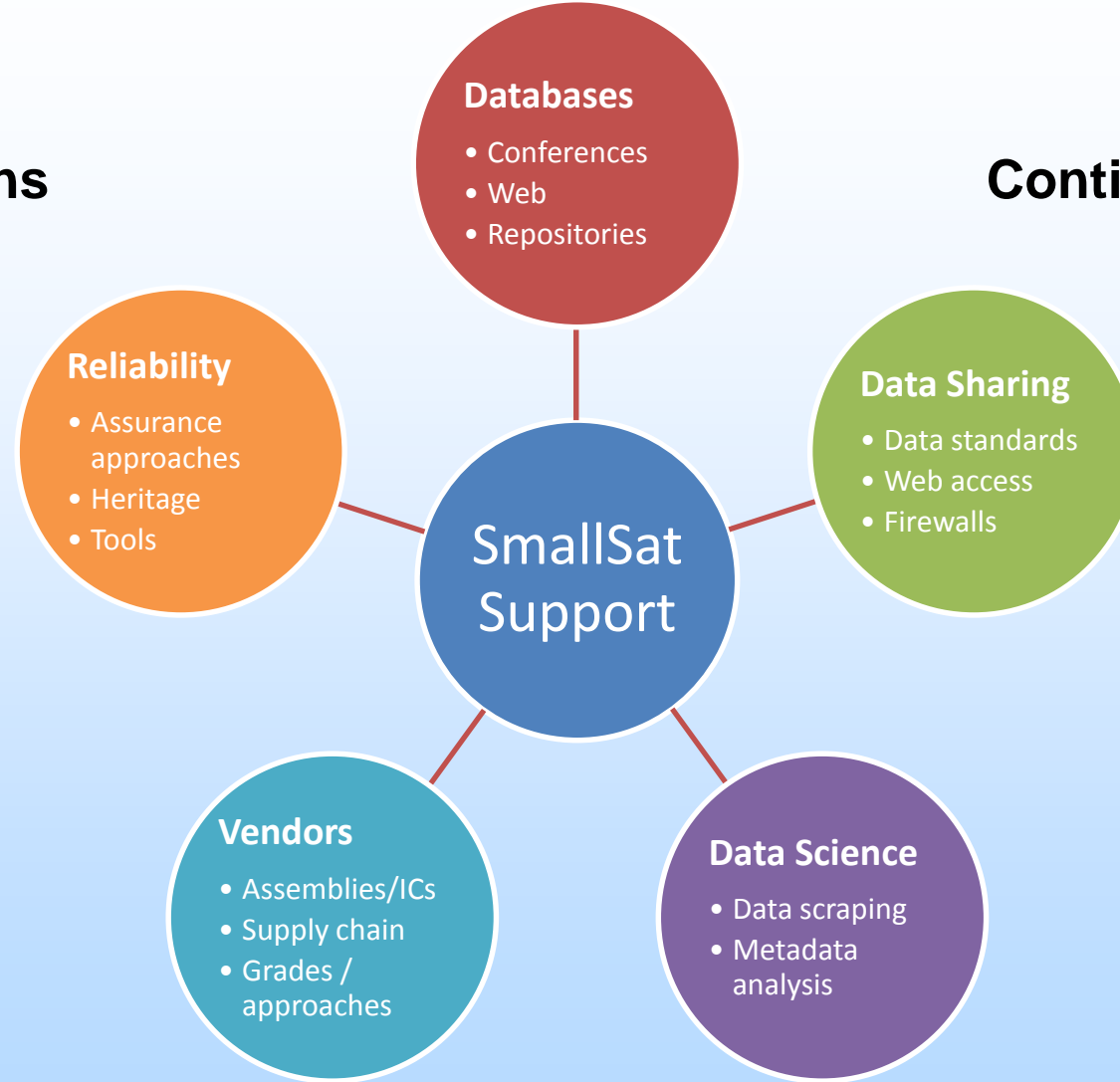


# Evolving Landscape for SmallSat Assurance Support

## Multiple Collaborations

- Academia
- Industry
- OGAs

## Continued focus on Model-Based Mission Assurance (MBMA)



***Accessible***

***Product-Focused***

***Linking Program Tasks to Community Focus Areas / Needs***



# NEPP Program / NEPAG Standards & Policy Development

- **Released NASA-STD-8739.10**
  - *NASA EEE Parts Assurance Standard*
  - Allows projects more flexibility to differentiate between critical/non-critical functions
- **Updating EEE-INST-002**
  - *Instructions for EEE Parts Selection, Screening, Qualification, and Derating*
  - Will unify Agency approaches through a single set of documentation
  - Goal is to modernize and synthesize existing Agency documents
  - Ongoing throughout FY19
- **Updating NPR-8705.4**
  - *Risk Classification for NASA Payloads*
  - Appendix C – Recommended SMA-Related Program Requirements for NASA Class A-D Payloads
  - Goal for EEE parts is a mapping that recommends parts with respect to payload class (A-D), mission criticality (critical/noncritical), and part grade level (space, military, industrial, COTS, etc.)

NASA Technical Standards: <https://standards.nasa.gov/>

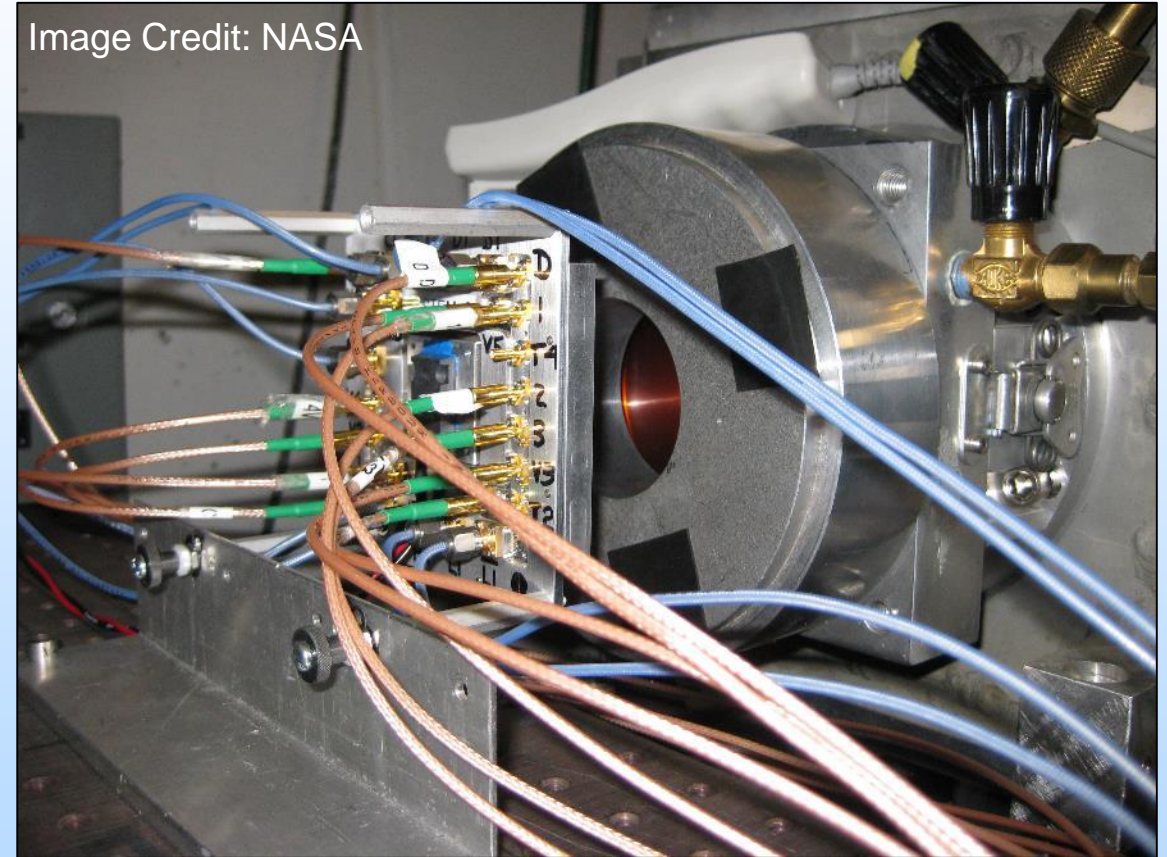
NASA Online Directives Information System (NODIS): <https://nodis3.gsfc.nasa.gov/>

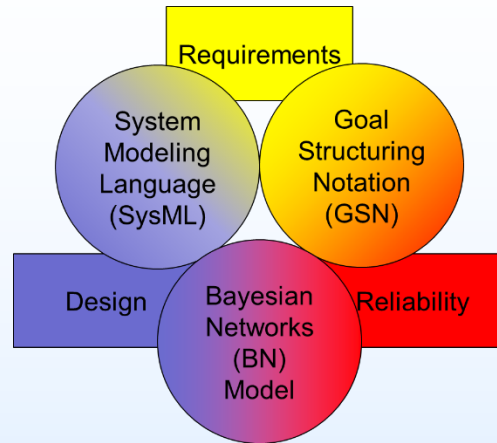




# As Always, Partnering is Essential

- **Within:**
  - NASA
- **With:**
  - Academia
  - Government agencies
  - Industry
  - International





*Emerging Assurance Methods*  
(Witulski, Vanderbilt University, NEPP ETW 2017)

Image credit: Vanderbilt / NASA

# 10<sup>th</sup> Annual NEPP Electronics Technology Workshop

**Scheduled dates:**  
Week of June 17, 2019  
NASA/GSFC and on-line

<https://nepp.nasa.gov/>



Image credit: NASA

*Radiation Testing*

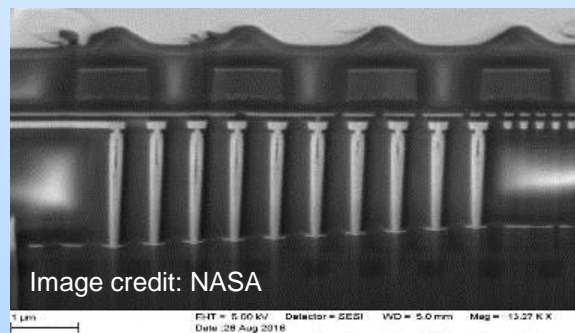


Image credit: NASA

*Advanced Technology Reliability*

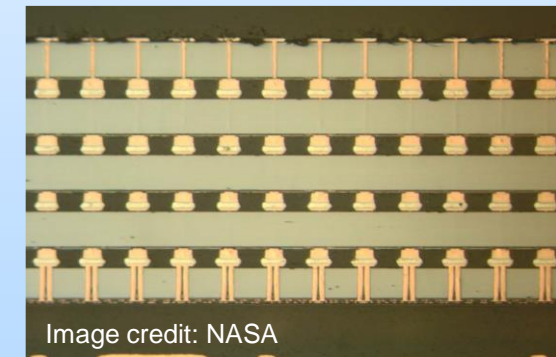


Image credit: NASA

*Commercial IC Packaging*



**21 (!) Exhibitors, Tutorial Speakers, Presenters, and the Committee  
look forward to seeing you at the**

**2019 Single Event Effects (SEE) Symposium and  
Military and Aerospace Programmable Logic Devices (MAPLD) Workshop**

**May 20-23, 2019**

**at the Marriott La Jolla, CA, USA**

**Registration is open and the technical program  
(great poster session too) is posted**

**Please see our website for additional information on the technical program (will be updated continuously),  
exhibits, registration, the hotel, and local arrangements.**

**<https://www.seemapld.org/>**